SHORTER ARTICLES AND DISCUSSION

NOTES ON THE FAUNA OF GREAT SALT LAKE

In the years during which the writer was zoologist at the University of Utah (1908–15) observations were made on the life of the Great Salt Lake, when time could be spared from multitudinous teaching duties. The animals of this brine lake earliest reported, *Artemia fertilis* Verrill, and the larvæ of the small Dipteron, *Ephydra gracilis* Packard, were naturally the first attraction, since they were abundant, commonly known to science, and readily observable to any one looking for them. A second species of *Ephydra, E. hians* Say, was reported by Aldrich in 1912.[1] A *Chironomus* has been reported also, according to Talmage,[2] but no reference to the authority is given and his own statement is confusing, as he says he has "confirmed the presence of . . . the larvæ of one of the Tipulidæ, probably *Chironomus oceanicus* Packard"! He further states that "The larvæ of the tipula may be taken anywhere near shore during the warm months," but the present writer is compelled to state that neither larvæ, pupæ or adults of either a Tipulid, or of a *Chironomus* was ever observed by him in the Lake, nor are any such reported by Aldrich, an authority on Diptera, in his reports of collecting about Great Salt Lake.[1, 3] Other forms than *Ephydra* might well occur in such a portion of the lake as the great Bear River Bay, where the salt content of the water must be much less, owing to a great influx of fresh water from the Bear River, and to the fact that the bay is partially cut off from the main lake by the causeway of the Southern Pacific Railway. Aldrich, however, has certainly been on the Bear River Bay side of the cut-off, as shown by Plate II, Fig. 8.[1]

In tentatively "trying out" to see what might be a profitable line of study several dilutions were made in order to note the

[1] Aldrich, J. M., "The Biology of Some Western Species of the Dipterous Genus *Ephydra*," *Jour. N. Y. Ent. Soc.*, XX, 77–99. In this are photographs indicating the enormous numbers of *Ephydra* in the lake; also first complete description of *E. gracilis*.

[2] Talmage, J. E., 1900, "The Great Salt Lake, Present and Past," 67–68.

[3] Aldrich, J. M., "Collecting Notes from the Great Basin and Adjoining Territory (Dipt., Col.)," *Ent. News*, XXIV, 214–221.

effect, if any, on *Artemia*. The brine varied in density in the lake at Saltair during the years of these observations, according to season and rainfall, and besides the annual fluctuations gradually became less dense on account of a cyclical period of heavier precipitation and consequent rise in level of the lake. In October, 1909, the density was 1.158, and in April, 1915, 1.136. Dilutions were made by addition of distilled water as nearly as was feasible to the following densities: 1.12, 1.10, 1.08, 1.06, 1.04, 1.02, 1.01[4] These dilutions were placed in small aquarium jars, filled only ¼ to ½ full, and covered to prevent entrance of dust, and undue evaporation. It may be said at once that while Schmankewitsch's classic observations on *Artemia* were of course in mind, it was not hoped to repeat them with the small amounts of water used. However, some data obtained, though incomplete, seems worth recording, since the present writer can scarcely hope ever to have further opportunity for pursuing this line of investigation to the extent it deserves. It is sincerely hoped that some one may be able to further investigate the fauna normal to the unusual ecological conditions of brine lakes.

Resistance of the adult *Artemias* to sudden changes in the concentration of the salts, while greater than anticipated, only showed that they could not indefinitely survive too great a change. Plunged into tap water, they appeared "heavy," sinking at once to the bottom, from which with most vigorous swimming movements they were barely able to rise. Exact data as to length of life in these solutions is not sufficient to offer, but in general they survive a change to completely fresh water but a few hours, and they do not survive for long periods in water in which the amount of salts has been reduced to less than half the normal. In stronger concentrations they survive for sufficiently long periods that it seems likely they would live therein for a normal life period if other conditions were favorable. Kellogg[5] had opportunity in the case of *A. franciscana* Kellogg to note differences in size, color and abundance of individuals which had developed in waters of different densities, and it is interesting to note that he found them largest in waters ranging from 1.11 to 1.13 in density. The latter figure is nearly the same as

[4] See article by Daines preceding this, with exact densities of one series. Part of these observations were made in collaboration with Daines.

[5] Kellogg, V. L., "A New *Artemia* and its Life Conditions," *Science*, N. S., XXIV, pp. 594–596.

that for Great Salt Lake water at the beginning of my observations, at which time the lake was in the rising period of its long cycle of rise and fall, which rise continued at least up to 1915. Some few years prior to 1909 the lake had been much lower and the water at nearly the saturation point for NaCl. I believe 1.13 is somewhere near the mean density for Great Salt Lake.

Interesting facts were noted concerning eggs contained in dilutions made in autumn (see annual cycle below). These hatched in a few days or weeks, and they first hatched in the most dilute water, next in the next more concentrated, and so on up the scale of concentration in nearly regular order. The conclusion naturally presents itself that the stimulus to development lies in the reduction in amount of salts present, but later it appeared (this point was not finally cleared up) that it lay rather in a lack of oxygen resulting from insufficient aeration of the water used. Young thus hatched never reached maturity.

Ephydra larvæ are even more abundant in the lake than *Artemias*. They were found to be remarkably resistant to changes in density of water, as well as to other changes in liquid environment. These larvæ will live at least for days in tap water, but whether they could be brought to maturity in this or in very dilute lake water was not determined. The fact that the puparia drift up on shore in great "windrows" has already been noted by Aldrich,[1] and in the *Canadian Entomologist* for 1891 (original article not seen). The countless swarms of imagoes may be seen by bathers resting on the surface of the water or flying up at will, and it was found to be an easy matter to obtain the eggs by imprisoning a number of these in a covered crystallization dish with clean bottom, partly filled with brine, showing, as suspected, that they drop the eggs freely into the water. As this was not done until near the close of my service in Utah, no experiments were made with the eggs, but attempts to hatch the eggs and rear the insects to the imago stage in dilute lake water and in fresh water should be made. As instances of the resistance of these larvæ may be mentioned the following: In more than one case the larvæ were observed to live months in brine which had evaporated to saturation, and beyond to the point of containing a heavy deposit of crystals and of being completely encrusted on top, and in one such case practically all of the water had disappeared. Among the salt crystals in the little remaining water the larvæ were somewhat inactive, but appeared to be in good condition when water to about the normal amount

was restored to the jar. *Artemia* is resistant to concentration, but not to the same degree as *Ephydra* larvæ. Again, in an attempt to kill larvæ without distortion some were placed in Perenyi's fluid and in this were capable of movement after more than twenty-four hours. In Flemming's fluid they live several times as long as *Artemia,* but I have no record of the exact length of time. I am able to verify with certainty Aldrich's belief that these larvæ do not rise to the surface for air.

Most important of the incomplete observations were those indicating the presence of Protozoa as normal inhabitants of Great Salt Lake. So far as I am aware, no Protozoa have been previously reported from brine lakes. Representatives of this group, notably *Amœbæ,* were first seen in the moderate dilutions after some weeks in the laboratory, which proved to be in a sense cultures. In March, 1910, several jars of a series, including one of undiluted lake water, contained an abundance of these forms. The specimens were of two or three varieties or species, by far the most common being very like *Amœba limax.* I should not have hesitated to call it that in a fresh-water culture. A class of some 15 students was well supplied with *Amœbæ* for laboratory work from one of these jars. Occasionally, in making microscopic examinations of the cultures other Protozoa were met with, but never in numbers. In fact only a single specimen at a time was the rule. Specimens of Ciliata were seen, some closely resembling a species of *Uroleptus,* while at least once a species of *Euglena* was definitely noted. *Chlamydomonas* appeared quite regularly and in great quantity in many of the cultures.[4] I believe several species of Protozoa to be present normally in the Great Salt Lake, but not generally very abundant, as many of my efforts to secure them directly from the lake were failures. However, some were certainly obtained directly from the more or less decayed masses of organic débris which collect in enormous quantity in the great stretches of shallow water along the very flat shore, which masses consist mainly of the gelatinous blue-green alga, *Aphanothece packardii.*[4] (This is the alga "of the *Nostoc* group" mentioned by Aldrich.) In this material it was expected there might be found Nematodes, as they are in so many cases adapted to unusual environment, and so commonly present in decaying substance, but none ever came under observation.

Perhaps a statement of the annual cycle of life of *Artemia* and *Ephydra* may be of interest. For the latter it may be said that

larvæ and pupæ are at all times of the year present in the lake, though less abundant in winter. In the winter months there are but few in the open water, but they are common in the débris above mentioned. Dates for first appearance of adults were not secured, though some appear as early as April; they become common by June, and in July and August are so exceedingly numerous as to be a serious nuisance at times about Saltair pavilion, wind conditions being apparently a determining factor in their coming in swarms about the bathhouses. Ordinarily they keep below the level of the floors, on the piles and on the water surface. Whether any eggs survive the winter can not be stated. There is no evidence of the pupæ surviving on shore, where thrown up by the waves. It seems likely that larvæ and pupæ which remain submerged are the principal, if not the sole means of surviving the winter period.

Adult *Artemias,* the females with fully developed egg sacs, are very plentiful throughout the summer and fall into October. In this month the temperature of the water falls from the summer temperatures of between 25° and 30° C. (exact summer maximum unknown to writer) to as low as 15°–18° C. In November with the temperature as low as 6° C. there may still be seen some few adults. At a December temperature of 1° C. and lower (doubtless goes lower at times for short periods) no adults can be found, as a rule, though reported by Talmage. An abundance of eggs can be secured in fall, winter and spring, especially in the débris near shore. Possibly some may settle into the smooth oolithic sand of the open lake bottom, but I have no evidence that such is the case, and the eggs tend rather to float than to sink. Young appear in April and May, abundantly in the latter month. The earliest record secured for young was March 12 (1910), when a number of minute young were taken. The temperature at that time was 9° C. It will be noticed that *Artemia* differs markedly in its long season of activity from its fresh-water cousin, *Branchipus,* which is so soon gone from its evanescent breeding pools. Correlated with this long active period is the continued presence of abundant water and food and an entire absence of enemies. Enemies play no part in keeping down the numbers of *Artemia,* or of *Ephydra* in the larval stage. In the midsummer bathing season both are present in myriads in the open water, but so transparent are they that the average bather, even the native Salt Laker, seldom notes their presence.

The insect fauna of the lake shore presents material for a study in itself, on which nothing has been published save the material on Diptera by Aldrich, already cited. At the University of Utah I left the beginning of a collection of insects taken in or on the waters of the lake, and I recall that a small Corisid was several times seen and some specimens of it taken swimming immersed in the brine near shore. The species appeared to be the same as one common in fresh and slightly salt and sulphur impregnated waters in the Salt Lake valley.

Probably correlated with the abundance of *Ephydra* adults as food, may be mentioned a "plague of spiders" with which the resort (Saltair) was troubled during one bathing season, about 1910. Several cases of persons being bitten by spiders were reported in one of the Salt Lake papers, though I can not vouch for their authenticity. Certain it is that spiders of more than one species were unusually numerous about the pavilion, as I personally observed, and I learned later that the employees went about with brooms every morning before the hour for opening and destroyed as many as possible. The forest of piles and underpinning beneath the structure, however, was an inexhaustible reservoir from which the supply was constantly renewed. After the close of the season, no other remedy having been found, some employees were kept busy for weeks in boats beneath the huge structure collecting and destroying the egg cocoons, and the next season there was no serious trouble. Many bushels were thus collected. The second autumn this task was again taken up, and since that time no further plague of spiders has appeared, but whether autumn cocoon collecting is still kept up I do not know. I have no doubt that the seemingly sudden appearance of the great numbers of spiders was in reality but the time when, owing to the availability of a great food supply and plenty of space for spreading webs, they reached a high point in numbers, the culmination of years of slow increase.

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ON THE FLORA OF GREAT SALT LAKE

VERY little investigation has been made of the plant life of Great Salt Lake, either of a scientific nature or otherwise. So far as the author of this paper knows, but one attempt has been made in the past so scientifically classify the flora of the lake, and